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First Named Inventor	Hopkins
Art Unit	1794
Examiner Name	Ferguson, Lawrence D.
Attorney Docket Number	HOP-1

ENCLOSURES (Check all that apply)

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SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No. : 10/728,321
Applicants : Hopkins
Filed : December 4, 2003
TC/A.U. : 1794
Examiner : Ferguson, Lawrence D.
Title : High Modulus Thermoplastic Films and
Their Use as Cash Register Tapes

Docket No. : HOP-1
Customer No. : 29698

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

BRIEF ON APPEAL

Sir:

The present Brief on Appeal is filed for the consideration of the Board of Patent Appeals and Interferences in accordance with 37 CFR §41.37 in response to the Final Action of May 12, 2008. A Notice of Appeal was filed on June 23, 2008.

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Real Party in Interest

The inventor, Mr. Thomas Hopkins of Greenville, South Carolina, is the real party in interest. The present application has not been assigned or licensed to any other entity.

Related Appeals and Interferences

There are no related appeals or interferences known to the applicant.

Status of Claims

Claim 1 – rejected
Claim 2 – rejected
Claim 3 – rejected
Claim 4 – rejected
Claim 5 – rejected
Claim 6 – rejected
Claim 7 – rejected
Claim 8 – rejected
Claim 9 – rejected
Claim 10 – rejected
Claim 11 – cancelled
Claim 12 – rejected
Claim 13 – rejected
Claim 14 – rejected
Claim 15 – rejected
Claim 16 – rejected
Claim 17 – rejected
Claim 18 – rejected
Claim 19 – rejected
Claim 20 – rejected
Claim 21 – cancelled
Claim 22 – withdrawn
Claim 23 – withdrawn
Claim 24 – withdrawn
Claim 25 – withdrawn
Claim 26 – withdrawn
Claim 27 – withdrawn
Claim 28 – withdrawn

Status of Amendments

No amendments have been filed since the Final Office Action of May 12, 2008.

Summary of Claimed Subject Matter

The present invention is directed to a thermoplastic film composite for use as a cash register or receipt tape. The primary advantage of such a composite tape is that it can be produced at thicknesses much less than those of conventional paper tapes, such that the receipt roll may be changed less frequently. In order to work in conventional thermal image printers without deforming the film is necessarily non-heat shrinkable. (See the specification, page 8, lines 4 – 6) Further, for printability a thermal image coating is present on one outer surface of the composite (Spec, page 6, line 30 – page 7, line 4) and for machinability in the printer an anti-static additive is contained in the opposed outer layer (Spec, page 6, lines 9 – 29). A pigment is present in at least one layer to provide visual contrast for the print. (Spec, page 6, lines 3 – 8) It has been found in accordance with the present invention that in order to work without jamming in the printer, the composite must have a 1% secant modulus in the machine direction of at least about 150,000 psi. (Spec, page 7, lines 23 – 28) Specifically, the present composite must be both thin enough and stiff enough to be used as a “drop-in” for a conventional point-of-sale cash receipt tape. This is the aspect of the invention that most clearly distinguishes it from the prior art.

Grounds of Rejection to be Reviewed on Appeal

Whether claims 1 – 3, 6 – 10, 12 – 14 and 17 – 20 are unpatentable under 35 USC §102(b) over Matsui et al. (US Patent No. 4,996,182).

Whether claims 4 – 5 and 15 – 16 are unpatentable under 35 USC §103(a) over Matsui et al. (US Patent No. 4,996,182).

Argument

The 102(b) Rejection over Matsui, et al.

Claims 1 – 3, 6, 8 – 10, 12 – 14, 18 – 20

Matsui, et al. is directed to a heat sensitive recording material, which, if one picks and chooses ones way through the specification, may be a multilayer composite film similar in many aspects to the present claimed composite. However, Matsui et al. fail to disclose a film composite that is at once thin enough and stiff enough to serve as a “drop-in” replacement for a conventional cash register receipt tape. Rather, Matsui appears to be directed to printable film composites for uses such as transparencies or stickers, although specific applications are not directly discussed. Regardless, Matsui et al. require that their composite contain minute cavities in order to obtain a clear, high density image at-low printing energies. It is this minimum required cavity content that renders the Matsui et al. composite useless as a conventional paper receipt replacement.

Figure 2 of the Matsui et al. patent shows the Young’s modulus of the film as a function of cavity content. At the lowest workable cavity content according to Matsui et al., 40 cc/100 g (See Matsui, et al., Col. 2, lines 53 – 58), the film has a modulus in the machine direction of approximately 102 kg/mm² (145,000 psi). From there the modulus drops as the cavity content increases.

The present claims require that the composite has a 1% secant modulus in the machine direction of at least about 150,000 psi. It is the Examiner’s position that the Young’s modulus of the Matsui, et al. composite of 145,000 psi equivalent to a 1% secant modulus of about 150,00 psi. Accordingly, a brief description of the relationship between these two types of modulus is necessary.

At its simplest, modulus is defined as stress over strain. Every film (in fact, every material) has its own stress/strain curve. Imagine gripping a length of plastic wrap from the kitchen at each end and pulling. Initially the film will stretch and if you release one end it will relax back to its initial size. This is the initial modulus, also

called the modulus of elasticity or the Young's modulus. If, however, you keep pulling, eventually the polymer chains that make up the film will start to flow past each other. If you then release one end the film will relax somewhat but it will not relax back to its original configuration. You've stretched it out of shape, so to speak. You've passed the elastic or proportional limit of the film. Now, imagine graphing this exercise. The stress you applied to the film by pulling can be defined as force over area of the film. The strain can be defined as the change in the length of the film. The initial pulling or stress, which results in complete recovery if you stop, is a straight line on the graph with strain increasing proportionally with stress. Along that line stress over strain is always the same and that is the modulus of elasticity or Young's modulus. After the elastic or proportional limit has been met the stress/strain curve is no longer a straight line. The curve drops off. Imagine that piece of plastic wrap again. Once you pull it past the elastic limit, it thins out, it's easier to pull. Attached in the Evidence Appendix is a typical stress/strain curve for a polymer taken from Polymer Science and Technology, Joel R. Fried, 1995, Prentice Hall PTR, pg.167, showing the initial, straight line portion of the curve followed by the dropping off of the curve after the polymer has reached its proportional limit. Also shown on this curve is the 1% secant modulus, which is the term used to define modulus in the present specification and claims. The 1% secant modulus is simply the ratio of stress to strain when the film has elongated 1%. In the attached curve, this 1% elongation is reached well after the elastic or proportional limit of the polymer. For particularly elastic films such 1% elongation may occur prior to reaching the elastic limit. For these films Young's modulus and 1% secant modulus are equal. However, most useful films are more resilient to deformation. Thus, they have a stress-strain curve that looks like the attached curve. The 1% secant modulus is on a line with a lesser slope than the initial or Young's modulus. Thus, we can conclude that the 1% secant modulus of a film will always be equal to or less than the Young's modulus of that same film.

Now, if the Young's modulus and the 1% secant modulus of the Matsui, et al. composite are equal we know that the composite is fairly elastic. Such an elastic film

would not be functional as a receipt tape replacement. Moreover, it would not be sufficiently machinable for the printing applications anticipated by Matsui, et al. Thus, it is reasonable to assume that the 1% secant modulus of the Matsui, et al. composite is actually less than its Young's modulus, and therefore, less than 145,000 psi and not *about* 150,000 psi.

Obviously, for the present claims, the rejection under 35 USC §102(b) can be overcome by removing the word "about" from the independent claims. But, such amendment would merely result in an obviousness rejection. It is Applicant's position that the present claims are neither anticipated nor rendered obvious by Matsui, et al. Simply put, extensive testing has shown that printable films having a 1% secant modulus much less than 150,000 psi are inoperable as register receipt replacements. Matsui, et al. teaches away from such stiff films as the cavity contents which result in films of marginal stiffness for use in the present invention are found to be inoperable in that reference. Accordingly, it is requested that the Board overturn the present Final rejection.

Claims 7 and 9

Dependent claims 7 and 9 each require that the present composite has a 1% secant modulus of at least about 200,000 psi. While Applicant strongly contends that the remaining claims are neither anticipated nor rendered obvious by Matsui, et al. while having a limitation of a 1% secant modulus of at least about 150,000 psi as argued above, clearly the present dependent claims are not suggested by that reference.

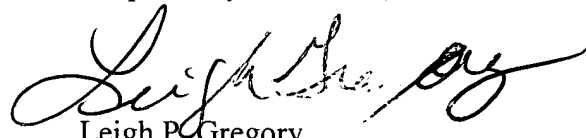
As noted above, Matsui, et al. disclose a composite having a Young's modulus which varies depending on cavity content. At the lowest workable cavity content the Matsui, et al. composite has a Young's modulus of 145,000 psi which necessarily translates into a 1% secant modulus of less than 145,000; and, the modulus drops as the cavity content increases. Accordingly, it is submitted that these claims are neither anticipated nor rendered obvious by Matsui, et al. and it is requested that the Board overturn the present Final rejection.

The 103(a) Rejection over Matsui, et al.

Claims 4, 5, 15, 16

These dependent claims address the preferred thicknesses for composites in accordance with the present invention. As noted at length above, the present invention is concerned with providing a thermoplastic composite which is sufficiently thin to serve as a conventional receipt tape replacement and which is sufficiently stiff to avoid jamming the printer. Although the overall thickness of the Matsui, et al. composite is not specifically disclosed, from a reading of that patent at Col. 4, lines 3 – 13 and a review of Table 2 of Example 2, it appears that Matsui, et al. provide for composites having thicknesses in the range of approximately 30 to 305 micrometers (roughly 1.18 to 12 mils), suggesting the possibility of some overlap with the less preferred higher end of the present claimed thickness range. However, as Matsui, et al. fail to recognize the criticality of the present claimed stiffness, it is submitted that the present claims are not rendered obvious by that reference. Accordingly, it is requested that the Board overturn the present Final rejection.

Respectfully Submitted,



Leigh P. Gregory
Reg. No. 33,241

7-25-08

Date

P.O. Box 168
Clemson, SC 29633
757-642-6039

Claims Appendix

1. (Previously presented) A multilayer, oriented thermoplastic composite for use as a register or receipt tape comprising:
 - an essentially non-heat shrinkable film having a first outer film surface and a second outer film surface, the film comprising a core layer, and at least a first outer layer having an outermost surface comprising the first outer film surface;
 - the first outer layer comprising a non-migratory anti-static additive; and
 - a heat sensitive, thermal image coating on the second outer film surface;
 - wherein at least one outer layer comprises a pigment and wherein the composite has a 1% secant modulus in the machine direction of at least about 150,000 psi.
2. (Original) A composite as set forth in claim 1 wherein the second outer film surface comprises an outermost surface of the core layer opposite to the first outer layer.
3. (Original) A composite as set forth in claim 1 further comprising a second outer layer having an outermost surface and wherein the outermost surface of the second outer layer comprises the second outer film surface bearing the heat sensitive, thermal image coating.
4. (Original) A composite as set forth in claim 1 having a thickness of from about 0.35 mils to about 1.5 mils.
5. (Original) A composite as set forth in claim 4 having a thickness of from about 0.50 mils to about 0.75 mils.

6. (Original) A composite as set forth in claim 3 wherein the core layer further comprises a cavitation promoting additive.
7. (Original) A composite as set forth in claim 1 having a 1% secant modulus in the machine direction of at least about 200,000 psi.
8. (Original) A composite as set forth in claim 1 wherein at least one of the layers comprises a polymer selected from the group consisting essentially of polyethylene, polypropylene, linear low density polyethylene, polystyrene and polyester.
9. (Original) A composite as set forth in claim 1 wherein the film is biaxially oriented.
10. (Original) A composite as set forth in claim 1 wherein the film is uniaxially oriented in the machine direction.
11. (Cancelled)
12. (Previously presented) An oriented thermoplastic composite for use as a register or receipt tape comprising:
 - an essentially non-heat shrinkable film having a first outer film surface and a second outer film surface, the film comprising at least a core layer;
 - an anti-static coating on the first outer film surface; and
 - a heat sensitive, thermal image coating on the second outer film surface;wherein at least one composite component comprises a pigment and wherein the composite has a 1% secant modulus in the machine direction of at least 150,000 psi.

13. (Original) A composite as set forth in claim 12 further comprising an outer layer having an outermost surface comprising the first outer film surface bearing the anti-static coating.
14. (Original) A composite as set forth in claim 12 further comprising an outer layer having an outermost surface comprising the second outer film surface bearing the heat sensitive, thermal image coating.
15. (Original) A composite as set forth in claim 12 having a thickness of from about 0.35 mils to about 1.5 mils.
16. (Original) A composite as set forth in claim 15 having a thickness of from about 0.50 mils to about 0.75 mils.
17. (Original) A composite as set forth in claim 12 having a 1% secant modulus in the machine direction of at least about 200,000 psi.
18. (Original) A composite as set forth in claim 12 wherein at least one layer comprises a polymer selected from the group consisting essentially of polyethylene, polypropylene, linear low density polyethylene, polystyrene and polyester.
19. (Original) A composite as set forth in claim 12 wherein the film is biaxially oriented.
20. (Original) A composite as set forth in claim 12 wherein the film is uniaxially oriented in the machine direction.
21. (Cancelled)

22. (Withdrawn) A method for making a thermoplastic composite suitable for use as a register or receipt tape, comprising the steps of:
- a. coextruding a multilayer film having a first outer film surface and a second outer film surface, the film comprising a core layer, and at least a first outer layer having an outermost surface comprising the first outer film surface, the first outer layer comprising a non-migratory anti-static additive, and at least one outer layer comprising a pigment;
 - b. orienting the film;
 - c. annealing the film; and
 - d. applying a heat sensitive, thermal image layer to the second outer film surface.
23. (Withdrawn) The method set forth in claim 22 wherein the step of orienting comprises biaxially orienting.
24. (Withdrawn) The method set forth in claim 23 wherein the product of the machine direction and transverse direction stretch ratios is from about 2.0X to about 50X.
25. (Withdrawn) The method set forth in claim 22 wherein the step of orienting comprises uniaxially orienting in the machine direction.
26. (Withdrawn) The method set forth in claim 25 wherein the machine direction stretch ratio is in the range of from about 1.5X to about 10.0X.
27. (Withdrawn) The method set forth in claim 22 wherein the step of coextruding comprises a blown film process.
28. (Withdrawn) The method set forth in claim 22 wherein the step of coextruding comprises a cast film process.

Evidence Appendix

Polymer Science and Technology

Joel R. Fried
University of Cincinnati



Prentice Hall PTR
Englewood Cliffs, New Jersey 07632

State Properties of Polymers

(4.42)

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(4.43)

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Table 4.13. For completely
within brackets in eq. 4.43 is
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RATIO OF
STRESSPoisson's
ratio

49
40
38
49
4

a relationship between stress

(4.44)

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le compliance, D , defined by

(4.45)

reciprocal of the modulus

Mechanical Properties

167

$$D = \frac{1}{E} \quad (4.46)$$

As shown by the representative stress-strain plot for a typical brittle polymer in Figure 4.18, only the initial portion of the plot follows Hookean behavior. The point at which stress begins to deviate from a linear stress-strain relation is called the *proportional limit*. This normally occurs before 1% strain. Therefore, to designate a value for the modulus, a convenient procedural definition must be adopted. Consequently, the initial slope of the stress-strain curve is called the *initial modulus*. Alternately, a line may be drawn from the origin to some convenient point along the stress-strain curve, for example, at 1% strain. This line defines a secant and the slope defines the *secant modulus*, the 1% secant modulus in this case. The modulus, or the compliance, is a *material property* that is a function of both temperature and the time scale of the deformation.

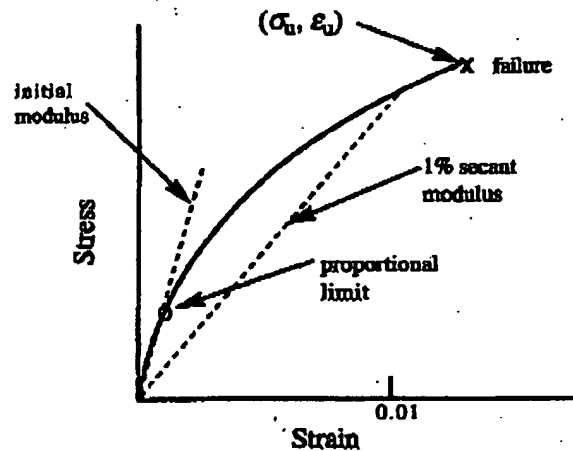


Figure 4.18. Representative stress-strain curve for a polymer undergoing brittle failure.

Figure 4.19 shows a representative plot of modulus versus temperature. At temperatures below T_g , all glassy materials, polymeric as well as low-molecular-weight substances, have approximately the same value of modulus (ca. 10^9 GPa). At first, this modulus slowly decreases with increasing temperature and then rapidly decreases in the region of T_g . For low-molecular-weight materials, modulus continues to fall rapidly with increasing temperature. For high-molecular-weight amorphous polymers, modulus drops to a secondary plateau region (approximately

[54] HEAT-SENSITIVE RECORDING MATERIAL

[75] Inventors: Takeshi Matsui; Takehiko Watanabe, both of Osaka; Katsunori Miyazaki, Inuyama; Hiroo Hayashi, Takatsuki, all of Japan

[73] Assignee: Toyo Boseki Kabushiki Kaisha, Osaka, Japan

[21] Appl. No.: 312,916

[22] Filed: Feb. 21, 1989

[30] Foreign Application Priority Data

Jun. 8, 1988 [JP] Japan 63-140911

[51] Int. Cl.⁵ B41M 5/18

[52] U.S. Cl. 503/200; 427/152; 503/226

[58] Field of Search 427/150-152; 428/319.9; 503/200, 226

[56] References Cited

FOREIGN PATENT DOCUMENTS

59-171685 9/1984 Japan .

59-225987 12/1984 Japan .

Primary Examiner—Pamela R. Schwartz

Attorney, Agent, or Firm—Cantor, Mueller & Player Wegner

[57] ABSTRACT

A heat-sensitive recording material which comprises a heat-sensitive recording layer and a substrate, the substrate having as a constituent element a synthetic resin film layer containing minute cavities and a content of cavities in the synthetic resin film layer being 40 to 100 cc/100 g. The heat-sensitive recording material has excellent resolution and gives a clear recorded image having a high density even with low printing energy.

5 Claims, 2 Drawing Sheets

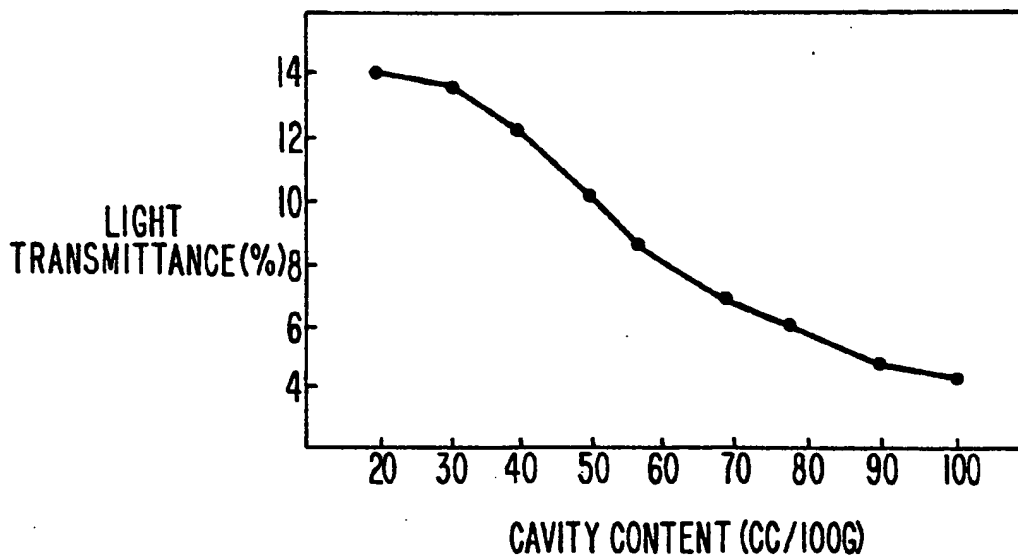
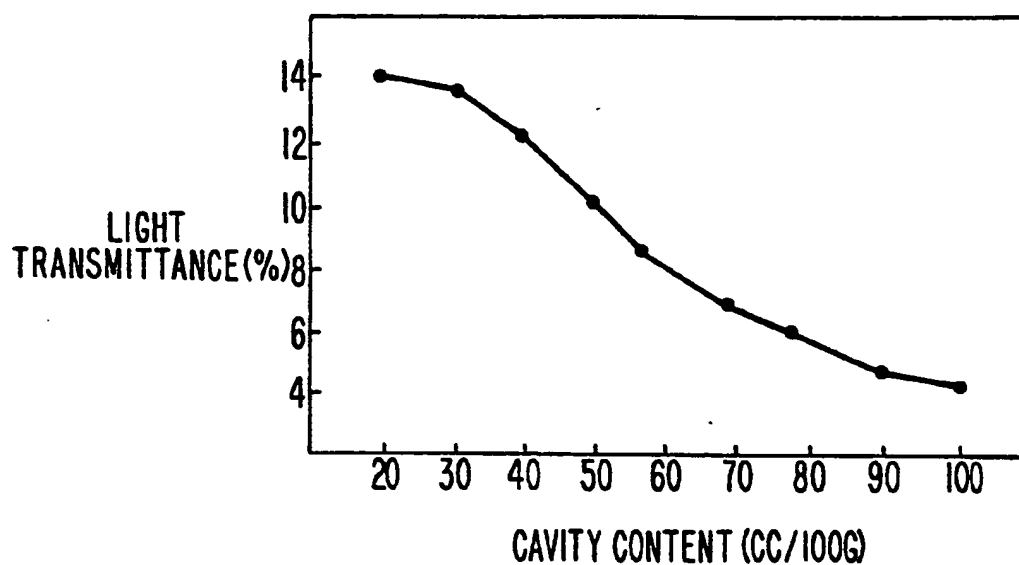
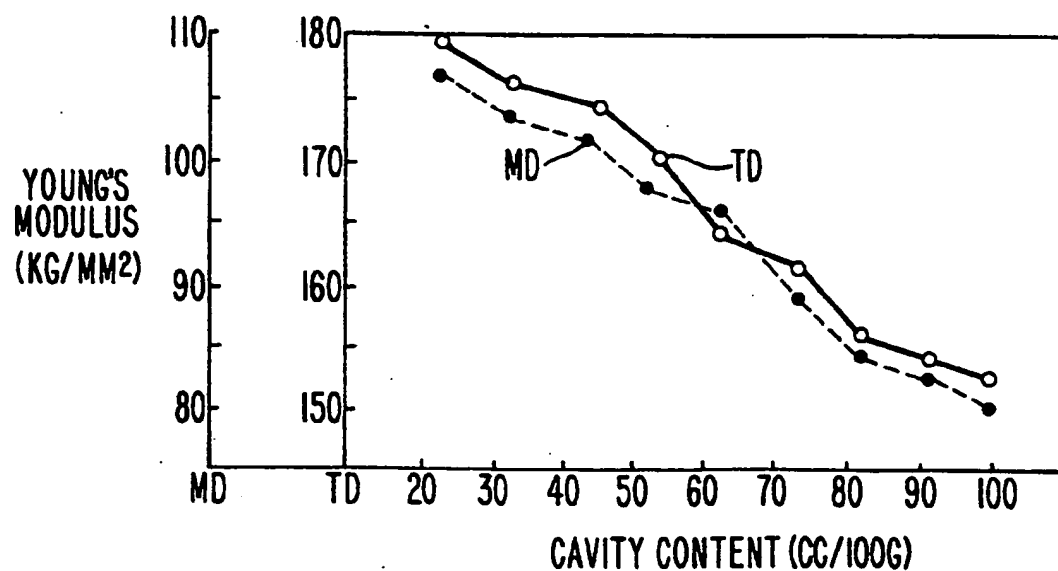


FIG. 1**FIG. 2**

HEAT-SENSITIVE RECORDING MATERIAL

FIELD OF THE INVENTION

The present invention relates to a heat-sensitive recording material such as a heat-sensitive recording paper or film which has excellent resolution and can give a clear recorded image in a high density.

BACKGROUND OF THE INVENTION

As heat-sensitive recording material, there has been known a material having a heat-sensitive layer on a substrate such as paper. In the heat sensitive layer, a color former and a color developer which produces color when it contacts with the color former, and a colored image can be obtained by heating with, what is called, a heating pen or thermal head.

Such a heat-sensitive recording material is relatively cheap and is used as a recording medium in various fields such as facsimile, various calculators, medical instruments, computers, heat-sensitive copying machines and printers of other various instruments and apparatus.

However, since development of various office machines and diversification of their use progress rapidly, it is desirable to develop a new heat-sensitive recording material which can meet respective requirements. For example, in order to meet requirements for making the operating speed of recording apparatuses fast, a recording material which can provide a clear image having a high density even with very low printing energy is desired. For this purpose, it has been recognized that not only a heat-sensitive layer itself but also its substrate should be studied and, thereby, use of synthetic paper or synthetic resin film instead of conventional natural paper have been increased.

As means to cope with low printing energy due to high-speed printing, for example, a heat-sensitive recording material disclosed in Japanese Patent Kokai No. 59-171685 has an undercoat layer containing minute cells and having excellent elasticity and heat insulating properties which is formed by providing a layer composed of a thermal expanding agent and a thermoplastic polymer on a substrate and heating the layer. In this heat-sensitive recording material, a clear recorded image having a relatively high density can be obtained even with low printing energy because of formation of the undercoat layer having elasticity and heat insulating properties. However, for producing the recording material, a step for expanding the thermal expanding agent is required. In addition, it is very difficult to control the degree of expansion in this step, and a uniformly expanded layer can hardly be obtained. Therefore, there is a defect in reproducibility of fine and thin images such as that required in, for example, a video printer. On the other hand, Japanese Patent Kokai No. 59-225987 discloses a method for improving evenness by providing a pigment coating layer on an expanded layer. However, since minute unevenness still remains on the recording layer, it is difficult to obtain a heat-sensitive recording material having sufficient resolution.

OBJECTS OF THE INVENTION

The main object of the present invention is to provide a heat-sensitive recording material such as a heat-sensitive recording paper or film which has excellent resolution

and can give a clear recorded image having a high density even with low printing energy.

This object as well as other objects and advantages of the present invention will become apparent to those skilled in the art from the following description with reference to the attached drawings.

BRIEF EXPLANATION OF DRAWINGS

FIG. 1 is a graph illustrating the relation between a content of cavities (cc/100 g) and transmittance (%) of the film containing cavities obtained in Example 1 hereinafter.

FIG. 2 is a graph illustrating the relation between a content of cavities (cc/100 g) and stiffness, i.e., Young's modulus (kg/mm²) of the film containing cavities obtained in Example 1 hereinafter.

FIG. 3 is an electron micrograph illustrating the cross sectional structure of the film No. 3 obtained in Example 1 hereinafter.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a heat-sensitive recording material which comprises a heat-sensitive recording layer and a substrate, said substrate having as a constituent element a synthetic resin film layer containing minute cavities and a content of cavities in said synthetic resin film layer being 40 to 100 cc/100 g. Particularly, when the synthetic resin film layer is composed of a mixture of a polyolefin and a substance immiscible with the polyolefin and is biaxially oriented, the resulting heat-sensitive recording material has especially excellent resolution. Further, when the synthetic resin film layer is laminated with a film layer made of a material which is the same as or different from that of the synthetic resin film layer, stiffness of the substrate can be controlled.

DETAILED DESCRIPTION OF THE INVENTION

In order to obtain a heat-sensitive recording material which can obtain a clear image having a high density even with low printing energy, the present inventors have studied intensively. As the result, it has been found that, when a synthetic resin film layer containing minute cavities is provided as a constituent element of a substrate of a heat-sensitive recording material, a clear image having a high density can be obtained even if picture quality is fine and thin. This results from heat insulating and cushioning properties of the synthetic resin film layer containing minute cavities which is provided under a heat-sensitive recording layer of the recording material.

The content of cavities in the synthetic resin film layer should be 40 to 100 cc/100 g. When the content of cavities is less than 40 cc/100 g, heat insulating and cushioning properties of the film become low and, thereby, a good image can be hardly obtained and opacity becomes inferior. On the other hand, the content of cavities is greater, heat insulating and cushioning properties of the film are better and, thereby, a better image can be obtained and opacity becomes better. However, when the content exceeds 100 cc/100 g, stiffness of the film becomes inferior.

The synthetic resin film having minute cavities used in the present invention can be produced as follows:

A synthetic resin and a substance which is immiscible in the resin are mixed, melted and extruded to obtain a non-oriented film. When the film is biaxially oriented

successively, cavities are formed toward the orientation direction due to the function of the immiscible substance as nuclei. In this case, when the draw ratio is higher and the orienting temperature is lower, more cavities are formed. Therefore, the content of cavities can be controlled by adjusting the draw ratio and the orienting temperature to obtain the desired content as described above.

As the synthetic resin, there can be used general-purpose synthetic resins such as polyolefins, polyamides, polyesters, polyvinyl chloride and the like. However, in view of suitable cushioning properties, easy film formation, stability against humidity and no generation of chlorine upon burning as well as from the economical viewpoint, polyolefins are preferred. As polyolefins, there can be used polyethylene, polypropylene, their copolymers, a mixture thereof and the like.

As the substance immiscible with the synthetic resin, there can be used inorganic substances or polymers which are immiscible with the above synthetic resins. In order to facilitate formation of minute cavities, inorganic substances are preferred. Examples of the inorganic substances include calcium carbonate, calcium oxide, silica, titanium oxide, alumina, aluminum sulfate and the like. Particularly, calcium carbonate is preferred. The particle size of the inorganic substance is preferably 0.1 to 15 μm , more preferably 0.5 to 10 μm . When the particle size is less than 0.1 μm , cavities are scarcely formed extending over the surface and inner part of the oriented film. When the particle size exceeds 15 μm , stretchability upon film formation becomes inferior. The amount of the inorganic substance to be admixed with the synthetic resin is preferably 5 to 50% by weight, more preferably 10 to 30% by weight based on the total weight of the resin and the inorganic substance. When the amount is less than 5% by weight, cavities are scarcely formed in the oriented film and the content of cavities is too low. On the other hand, when the amount exceeds 50%, stretchability upon film formation becomes inferior. Other immiscible substances can be used under similar conditions to those for inorganic substances.

Further, upon production of the synthetic resin film, titanium oxide and the like can be added to adjust whiteness and opacity of the film. Furthermore, other additives, for example, stabilizers, antistatic agents, dyes, pigments and the like can be added in so far as the properties of the film is not impaired. Alternatively, an antistatic agent or the like can be coated on the synthetic resin film.

These synthetic resin films are disclosed in Japanese Patent Kokoku Nos. 54-31030, 54-31032, 54-31033 and 54-31034, which correspond to U.S. Pat. No. 3,773,608, as well as Japanese Patent Kokai Nos. 57-181829 and 58-220139.

In the heat-sensitive recording material of the present invention, usually, the synthetic resin film thus produced can be used as a substrate itself and a heat-sensitive recording layer can be directly provided on the synthetic resin film layer. However, in the case that adhesion between the heat-sensitive recording layer and the synthetic resin film layer is poor, a middle layer such as a suitable anchor coat layer or adhesive layer can be provided between the recording layer and the synthetic resin film layer. Further, in the case that stiffness of the synthetic resin film is insufficient, a core layer can be provided under the synthetic resin film layer.

These middle layers and core layers themselves are known in the art and are not specifically limited.

Preferably, the substrate has a layer of the synthetic resin film containing cavities of at least 4 μm in thickness. For example, in the case that the substrate is composed of only a layer of the synthetic resin film containing minute cavities, the substrate is preferably 30 to 300 μm in thickness. In the case that the substrate is a laminate of the synthetic resin film containing minute cavities and a film containing no cavity (core layer), the substrate is preferably 25 to 300 μm in thickness and has a layer of the synthetic resin film containing minute cavities of at least 4 μm in thickness.

Typical examples of the laminated structure of the heat-sensitive recording material of the present invention are as follows:

C/A/B and C/A/B/A

wherein A is the synthetic resin film containing minute cavities, B is a film having no cavity (core layer) and C is the heat-sensitive recording layer.

Further, in the case that the synthetic resin film containing minute cavities is exposed to the back surface, a thin layer film can be provided on the surface of the synthetic resin film layer to prevent removal of the inorganic substance contained therein.

The heat-sensitive recording layer is provided on such a substrate composed of the synthetic resin film layer alone or in combination thereof with the middle layer and/or the core layer. The heat-sensitive recording layer is not specifically limited, either and there can be used any conventional heat-sensitive recording layer which contains a color producing agent and a color developing agent which can produce color by contacting with the color producing agent. For example, there can be used a combination of a colorless or pale colored basic dye and an inorganic or organic acidic substance, or a combination of a higher fatty acid metal salt such as ferric stearate and a phenol such as gallic acid. Further, it is possible to use a combination of a diazonium compound, a coupler and a basic substance.

As the above colorless or pale colored basic dye (color former), there can be used known dyes, for example, triarylmethane dyes such as 3,3-bis(p-dimethylaminophenyl)-6-dimethyl-aminophthalide, 3,3-bis(p-dimethylaminophenyl)-phthalide, 3-(p-dimethylamino-phenyl)-3-(1,2-dimethylindol-3-yl)-phthalide, 3-(p-dimethylaminophenyl)-3-(2-methylindol-3-yl)phthalide, 3,3-bis(1,2-dimethylindol-3-yl)-5-dimethylaminophthalide, 3,3-bis(1,2-dimethylindol-3-yl)-6-dimethylaminophthalide, 3,3-bis(9-ethylcarbazol-3-yl)-6-dimethylaminophthalide, 3,3-bis(2-phenylindol-3-yl)-6-dimethylaminophthalide, 3-p-dimethylaminophenyl-3-(1-methylpyrrol-3-yl)-6-dimethylamino-phthalide and the like; diphenylmethane dyes such as 4,4'-bis-dimethylaminobenzhydryl benzyl ether, N-halophenyl-leucoauramine, N-2,4,5-trichlorophenyl-leucoauramine and the like; thiazine dyes such as benzoylleucomethylene blue, p-nitrobenzoyl-leucomethylene blue and the like; spiro dyes such as 3-methyl-spiro-dinaphthopyran, 3-ethyl-spiro-dinaphthopyran, 3-phenyl-spiro-dinaphthopyran, 3-benzyl-spiro-dinaphthopyran, 3-methylnaphtho-(6'-methoxybenzo)-spiropyran, 3-propyl-spiro-dibenzopyran and the like; lactum dyes such as rhodamine B anilinolactum, rhodamine(p-nitroanilino)lactum, rhodamine(o-chloroanilino)-lactum and the like; and fluorane dyes such as 3-dimethylamino-7-methoxyfluorane, 3-diethylamino-6-methoxyfluorane, 3-diethylamino-7-methoxyfluorane, 3-diethylamino-7-

chlorofluorane, 3-diethylamino-6-methyl-7-chlorofluorane, 3-diethylamino-6,7-dimethylfluorane, 3-(N-ethyl-p-toluidino)-7-methylfluorane, 3-diethylamino-7-N-acetyl-N-methylaminofluorane, 3-diethylamino-7-N-methylaminofluorane, 3-diethylamino-7-dibenzylaminofluorane, 3-diethylamino-7-N-methyl-N-benzylaminofluorane, 3-diethylamino-7-N-chloroethyl-N-methylaminofluorane, 3-diethylamino-7-N-diethylaminofluorane, 3-(N-ethyl-p-toluidino)-6-methyl-7-phenylaminofluorane, 3-(N-cyclopentyl-N-ethylamino)-6-methyl-7-anilino-10 fluorane, 3-(N-ethyl-p-toluidino)-6-methyl-7-(p-toluidino)fluorane, 3-diethylamino-6-methyl-7-phenylaminofluorane, 3-diethylamino-7-(2-carbomethoxyphenylamino)fluorane, 3-(N-ethyl-N-isoamylamino)-6-methyl-7-phenylaminofluorane, 3-(N-cyclohexyl-N-methylamino)-6-methyl-7-phenylaminofluorane, 3-piperidino-6-methyl-7-phenylaminofluorane, 3-piperidino-6-methyl-7-phenylaminofluorane, 3-diethylamino-6-methyl-7-xylydinofluorane, 3-diethylamino-7-(o-chlorophenylamino)fluorane, 3-dibutylamino-7-(o-chlorophenylamino)fluorane, 3-pyrrolidino-6-methyl-7-p-butylphenylaminofluorane, 3-N-methyl-N-tetrahydrofurfurylamino-6-methyl-7-anilino-15 fluorane, 3-N-ethyl-N-tetrahydrofurfurylamino-6-methyl-7-anilino-25 fluorane and the like.

As the acidic inorganic or organic substance (color developer) which can produce color by contacting with the basic dye, there can be used known acidic inorganic substances, for example, activated clay, acid clay, attapulgite, bentonite, colloidal silica, aluminum silicate and the like, and known organic acidic substances, for example, phenolic compounds such as 4-tert-butylphenol, 4-hydroxydiphenoxide, α -naphthol, β -naphthol, 4-hydroxyacetophenol, 4-tert-octylcatechol, 2,2'-dihydroxydiphenol, 2,2'-methylenebis(4-methyl-6-tert-butylphenol), 4,4'-isopropylidenediphenol (bisphenol A), 2,2'-methylenebis(4-chlorophenol), hydroquinone, 4,4'-cyclohexylidenediphenol, benzyl 4-hydroxybenzoate, dimethyl 4-hydroxyphthalate, hydroquinonemonobenzyl ether, novolak phenolic resin, phenol polymers and the like; aromatic carboxylic acids such as benzoic acid, p-tert-butylbenzoic acid, trichlorobenzoic acid, terephthalic acid, 3-sec-butyl-4-hydroxybenzoic acid, 3-cyclohexyl-4-hydroxybenzoic acid, 3,5-dimethyl-4-hydroxybenzoic acid, salicylic acid, 3-isopropylsalicylic acid, 3-tert-butylsalicylic acid, 3-benzylsalicylic acid, 3-(α -methylbenzyl)salicylic acid, 3-chloro-5-(α -methylbenzyl)salicylic acid, 3,5-di-tert-butylsalicylic acid, 3-phenyl-5-(α , α -dimethylbenzyl)salicylic acid, 3,5-di- α -methylbenzylsalicylic acid and the like; and salts of the above phenolic compounds and aromatic carboxylic acids with polyvalent metals such as zinc, magnesium, aluminum, calcium, titanium, manganese, tin, nickel and the like.

The above basic dyes (color formers) and color developers can be used alone or in combination thereof. The ratio of the basic dye and the color developer is not specifically limited and can be appropriately chosen according to particular dye and color developer to be used. Usually, the color developer can be used in an amount of 1 to 20 parts by weight, preferably 2 to 10 parts by weight per 1 part by weight of the basic dye.

A coating composition containing these substances is prepared by dispersing the dye (color former) and the color developer in a dispersion medium such as, in gen-

eral, water simultaneously or separately with an agitator or grinder such as ball mill, attritor mill, sand mill or the like.

In the coating composition, a binder is added in an amount of about 2 to 40% by weight, preferably 5 to 25% by weight based on the total solids constituent of the composition. Examples of the binder include starches, hydroxyethyl cellulose, methyl cellulose, carboxymethylcellulose, gelatin, casein, gum arabic, polyvinyl alcohol, acetoacetyl modified polyvinyl alcohol, diisobutylene-maleic anhydride copolymer salt, styrene-maleic anhydride copolymer salts, ethylene-acrylic acid copolymer salts, styrene-butadiene copolymer emulsion, urea resin, melamine resin, amide resin, amino resin and the like.

Further, if necessary, various auxiliaries can be added to the coating composition. Examples of auxiliaries include dispersants such as sodium dioctylsulfosuccinate, sodium dodecylbenzenesulfonate, sodium lauryl sulfonate, metal salts of fatty acids and the like; anti-foaming agents; fluorescent dyes; colorants; electrically conducting substances and the like.

Furthermore, if necessary, the coating composition can contain waxes such as zinc stearate, calcium stearate, polyethylene wax, carnauba wax, paraffin wax, ester wax and the like; fatty acid amides such as stearic acid amide, stearic acid methylene bis amide, oleic acid amide, palmitic acid amide, coconut fatty acid amide and the like; hindered phenols such as 2,2'-methylenebis(4-methyl-6-tert-butylphenol), 1,1,3-tris(2-methyl-4-hydroxy-5-tert-butylphenyl)butane and the like; ultraviolet absorbers such as 2-(2'-hydroxy-5'-methylphenyl)benzotriazole and the like; benzophenones such as 2-hydroxy-4-benzyl-oxybenzophenone and the like; esters such as 1,2-di(3-methylphenoxy)ethane, 1,2-diphenoxyethane, 1-phenoxy-2-(4-methylphenoxy)ethane, dimethyl terephthalate, dibutyl terephthalate, dibenzyl terephthalate, p-benzylbiphenyl, 1,4-dimethoxynaphthalene, 1,4-diethoxynaphthalene, phenyl 1-hydroxynaphthoate and the like; various known heat fusible substances; and inorganic pigments such as kaolin, clay, talc, calcium carbonate, calcined clay, titanium oxide, diatomaceous earth, finely divided anhydrous silica, activated clay and the like.

In the heat-sensitive recording material of the present invention, the formation of the heat-sensitive recording layer is not specifically limited and, for example, it is formed by coating the coating composition according to air-knife coating, blade coating or the like and then drying the resulting coat. Further, the coating weight is not specifically limited either and, usually, the layer is prepared in the dry weight range of about 2 to 12 g/m², preferably, about 3 to 10 g/m².

Optionally, on the surface of the heat-sensitive recording layer of the recording material, it is possible to provide an overcoat layer to protect the recording layer according to a known method. Further, there can be employed various known modifications in the field of heat-sensitive recording materials. For example, a pressure-sensitive adhesive layer can be provided on the back surface of the recording material to obtain a pressure-sensitive adhesive label.

The following Examples further illustrate the present invention in detail but are not to be construed to limit the scope thereof. In the Examples, all "parts" and "%s" are by weight unless otherwise stated.

In the Examples, properties were determined as follows:

(1) Opacity

According to JIS K 6714, the total luminous transmittance of a sample was determined. The evaluation in the Examples were carried out according to the following criteria:

A: total luminous transmittance of less than 5%

B: total luminous transmittance of 5% to less than 9%

C: total luminous transmittance of 9% to less than 15%

D: total luminous transmittance of more than 15%

A sample having a lower transmittance has better opacity.

(2) Apparent density

The apparent density was calculated by the weight of a unit volume of a sample according to the following equation:

$$\text{Apparent density} = \text{Weight/Volume}$$

wherein Volume is that of a sample of 10 cm×5 cm×cm in thickness (cm³); and Weight is that of the sample of such a volume (g).

(3) Cavity content

Cavity content is corresponding to the volume of cavities in 100 g of a synthetic resin film and calculated by the following equation:

$$\text{Cavity content} = 100 \times \left(\frac{1}{D} - \frac{\sum M_i/\rho_i}{100} \right)$$

wherein M_i is a mixing ratio (%) of each ingredient; ρ_i is a density of each ingredient; and D is the apparent density of an oriented film.

(4) Evaluation of recorded picture quality

A recorded image obtained by a commercially available video printer (UP-103 manufactured by Sony Corporation, Japan) was measured by Macbeth densitometer (RD-914 manufactured by Macbeth Company) and a part of the recorded image having a recorded density of about 0.6 was evaluated as follows:

The recorded part was divided into three areas of high density area, low density area and blank area by using a dot analyzer (DA-2000 manufactured by Kanzaki Paper Mfg. Co., Ltd., Japan). The ratio of the high density area was calculated and evaluated according to the following criteria:

A: high density area being more than 45%

B: high density area being 40% to less than 45%

C: high density area being 30% to less than 40%

D: high density area being 20% to less than 30%

E: high density area being less than 20%

The results are quite consistent with visual evaluation and a sample having a higher ratio of a high density area has better picture quality.

(5) Evaluation of stiffness

According to ASTM D882, Young's modulus (kg/mm²) toward the machine direction (MD) and that toward the transverse direction (TD) were determined and stiffness was evaluated according to the following criteria:

A: MD of not less than 120 and TD of not less than 200

B: MD of 85 to less than 120 and TD of 150 to less than 200

C: MD of 50 to less than 85 and TD of 100 to less than 150

D: MD of less than 50 and TD of less than 100

A sample having higher MD and TD has better stiffness.

The coating composition for formation of the heat-sensitive recording layer by coating it on the substrate was prepared as follows:

Preparation of dispersion A		
Ingredients		Parts
3-(N-ethyl-N-isoamylamino)-6-methyl-7-phenylamino-fluorane		10
Dibenzyl terephthalate		20
5% Aqueous solution of methyl cellulose		20
Water		40

The ingredients were mixed and the mixture was ground with a sand mill until the average particle size reached 3 μ m.

Preparation of dispersion B		
Ingredients		Parts
4,4'-isopropylidene diphenol		30
5% Aqueous solution of methyl cellulose		40
Water		20

The ingredients were mixed and the mixture was ground with a sand mill until the average particle size reached 3 μ m.

Preparation of coating composition

The above dispersions A (90 parts) and B (90 parts), silica pigment (Mizukasil P-527 manufactured by Mizusawa Kagaku K.K., Japan: average particle size: 1.8 μ m : oil absorption: 180 cc/100 g) (30 parts), 10% aqueous polyvinyl alcohol solution (300 parts) and water (28 parts) were mixed and stirred to obtain the coating composition.

EXAMPLE 1

A mixture of polypropylene (MI=4) (70%), polyethylene (MI=0.5) (20%) and calcium carbonate (particle size: 5 μ m) (10%) was subjected to melt extrusion at 270° C. After cooling, the extruded film was subjected to successive biaxial orientation to obtain a synthetic resin film having minute cavities of 100 μ m in thickness. At this time, the orientation conditions were varied to obtain synthetic resin films having different contents of cavities. The relation between cavity content and luminous transmittance (opacity) of the resulting film is shown in the attached FIG. 1. The relation between cavity content and stiffness of the resulting film (Young's modulus) is shown in the attached FIG. 2.

A heat-sensitive recording material was obtained by coating an aqueous coating solution of a polyethylene imine anchoring agent and silica as an antiblocking agent on the synthetic resin film to provide an anchor coat layer, coating the above-prepared coating composition for the heat-sensitive recording layer thereon so that the dry coating weight became 5 g/m², drying the layer and then supercalendering the resultant.

The properties of the resulting recording material are shown in Table 1. In Table 1, there are also shown the properties of a film obtained according to the same manner as described above except that paper or a polyester (PET) film is used as the substrate.

TABLE 1

No.	1	2	3	4	5	6	7
Cavity content (cc/100 g)	35	40	60	80	100	paper	Milky PET 80 μ m

TABLE 1-continued

No.	1	2	3	4	5	6	7
Picture quality	C	B	A	A	B	E	D
Opacity	C	B	B	A	A	A	B
Stiffness	A	B	B	C	C	A	A

The cross sectional structure of the film No. 3 is shown in FIG. 3 which is an electron micrograph (scanning electron microscope, $\times 500$).

EXAMPLE 2

A mixture of polypropylene (MI=4) (70%), polyethylene (MI=0.5) (20%) and calcium carbonate having particle size of 5 μm (10%) (for the film layer containing cavities), and a mixture of polypropylene (MI=4) (95%) and titanium oxide (5%) (for the core layer) were co-extruded at 280° C. to obtain a non-oriented three-layer film. Then, the film was subjected to orientation by adjusting the orienting temperature and the draw ratio in orientation toward the machine direction so that the cavity content of the cavity containing film layer in the final oriented film became 60 cc/100 g and then the film was oriented toward transverse direction to obtain the substrate of a heat-sensitive recording material.

Then, according to the same manner as described in Example 1, the coating composition for the heat-sensitive recording layer was coated on the substrate to obtain a heat-sensitive recording material having the above laminated structure of C/A/B/A (C: heat-sensitive recording layer, A: layer of the synthetic resin film containing minute cavities, B: core layer).

The properties of the film are shown in Table 2. In Table 2, the properties of the above No. 3 in Table 1 (cavity content: 60 cc/100 g) are also disclosed.

TABLE 2

No.	8	9	10	11	3
Thickness of C/A/B/A (μm)	5/2/76/2	5/5/70/5	5/10/60/5	5/15/50/15	no core
Picture quality	C	B	A	A	A

TABLE 2-continued

No.	8	9	10	11	3
Opacity	C	C	B	B	B
Stiffness	A	A	A	A	B

As seen from Table 1, when the cavity content is not less than 40 cc/100 g, the recording materials have good picture quality as well as good opacity. As seen from Table 2, when a core layer is laminated, stiffness is improved.

As described hereinabove, the heat-sensitive recording material of the present invention has excellent resolution and it is possible to obtain a clear recorded image having a high density even with low printing energy.

What is claimed is:

1. A heat-sensitive recording material which comprises a substrate and a heat-sensitive recording layer formed thereon, said substrate having as a constituent element a synthetic resin film layer containing minute cavities, said synthetic resin film layer being biaxially oriented and comprising a mixture of a polyolefin or a polyester and a particulate substance immiscible with the polyolefin or polyester, wherein a content of cavities in said synthetic resin film layer is 40 to 100 cc/g.

2. A heat-sensitive recording material according to claim 1, wherein the substance immiscible with the polyolefin is an inorganic substance and the amount thereof is 5 to 50% by weight based on the total amount of the inorganic substance and the polyolefin.

3. A heat-sensitive recording material according to claim 1, wherein the substrate comprises the synthetic resin film layer laminated with a second film layer made of a material which is the same as or different from that of the synthetic resin film layer, said second film layer being laminated on a surface of the synthetic resin film layer opposite to the heat-sensitive recording layer.

4. A heat-sensitive recording material according to claim 3, wherein said second film layer comprises a layer of a synthetic resin film containing no cavities.

5. A heat-sensitive recording material according to claim 4, further comprising another layer of the synthetic resin film containing minute cavities laminated on the surface of said layer of a synthetic resin containing no cavities opposite to said heat-sensitive recording layer.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,996,182

DATED : February 26, 1991

INVENTOR(S) : Takeshi MATSUI et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the cover page of the patent, under the heading entitled "Assignee:", insert the following after "Osaka, Japan":

-- and Kanzaki Paper Mfg. Co., Ltd.
Tokyo, Japan --

Signed and Sealed this
Fifteenth Day of September, 1992

Attest:

DOUGLAS B. COMER

Attesting Officer

Acting Commissioner of Patents and Trademarks

Related Proceedings Appendix

None.